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ESTIMATION OF SURVIVAL AND GROWTH POTENTIALS OF NURSERY STOCK BY USING A "VARIABLE-MOISTURE-STRESS-PLOT" TECHNIQUE

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ABSTRACT

A semicontrolled technique for testing the survival and growth potentials of conifer nursery stock under several soil-moisture-stress levels is described. The technique permits relatively efficient mass testing under conditions that virtually eliminate many of the extraneous variables associated with field testing. Some examples of test results are presented.

DIOT

One of the prime functions of nurserymen and scientists engaged in nursery work is to improve the field performance of nursery-grown stock. Any change in nursery culture or stock handling practice must, regardless of early indications based upon general stock appearances or cost, face the ultimate test of what this change does to the ability of the stock to *survive* and *grow* under the rigors of field planting. Consequently, accurate and efficient evaluation of stock survival and growth potentials is an important function for those engaged in the production of forest planting stock.

This evaluation of stock capabilities takes on many different forms ranging from direct observations of performance in the field to indirect evaluation based upon real or imagined correlations, and from crude ocular estimates to scientifically sophisticated determinations. One of the most perplexing problems is choosing a technique that gives an accurate estimate of performance quickly and inexpensively. The ultimate means for accomplishing this is probably a well-designed field test, adequately replicated, repeated over a period of from 3 to 5 years to sample varying weather effects, and carefully controlled to minimize the confounding effects of extraneous variables, such as differences in planting skill, competing vegetation, diseases, insects, and animal damage. If all of these criteria are satisfied, excellent information should be obtained; however, the cost is high and results are slow to achieve.

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Several years ago it became obvious to those of us associated with the planting program in the Northern Region of the USDA Forest Service that a good substitute for or supplement to field testing was needed. Previously, at least one major study effort was largely invalidated by a year during which the weather was extremely favorable for survival. Results of other studies were inconclusive owing to our inability to devote the time and money required for good long-term field testing. We therefore also concluded that expensive field testing of stock performance would have to be limited only to studies involving especially important questions and decisions.

We decided that an improved testing technique should allow us to determine the relative ability of different types of stock to survive under uniformly applied levels of moisture stress, because moisture stress has been proven to be the greatest single cause of field mortality, and is the climatic variable that most often confounds a single year's field testing. We also sought to insure that our technique would (a) minimize extraneous variables, such as animal damage, stock handling variables, and planting differences; (b) permit a large number of treatments to be replicated without the expense of individual tree marking; and (c) require a minimum of travel expense.

METHODS

The "Variable-Moisture-Stress-Plots" have been used to test the survival potential of various types of nursery stock on the Coeur d'Alene nursery for 3 years (1965-67). In our initial trial we used four stress levels (designated as low, moderate, high, and severe) in which stress was controlled by combinations of irrigation, weeding, no care, and shielding from natural precipitation. The extra precaution of a shielded plot (severe stress) was subsequently abandoned in favor of a three-stress-level approach. The given stress levels are maintained on adjacent "plots" in which seedlings from the nursery treatments being tested are planted approximately 1 foot apart in rows 18 inches apart (fig. 1). Rows of trees extend through the range of moisture stress being used; 24 trees are planted in each stress plot. Test trees are planted in April, May, or June and their survival and growth are examined throughout the first growing season and, depending on the circumstances, into the second or third season.. In order to standardize planting and reduce planting variability, seedlings are threaded into an eight-tree Yale Board under shelter and positioned in a plowed trench that has one vertical side. The trench is promptly backfilled and the soil packed into place (figs. 1 and 2). The soil is brought to field capacity when the seedlings are planted; after a day's planting, it is sprinkled to facilitate settling.

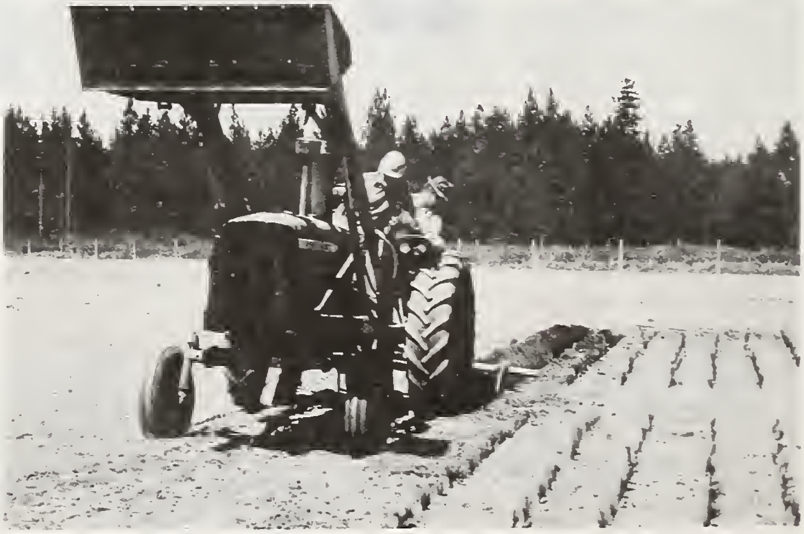
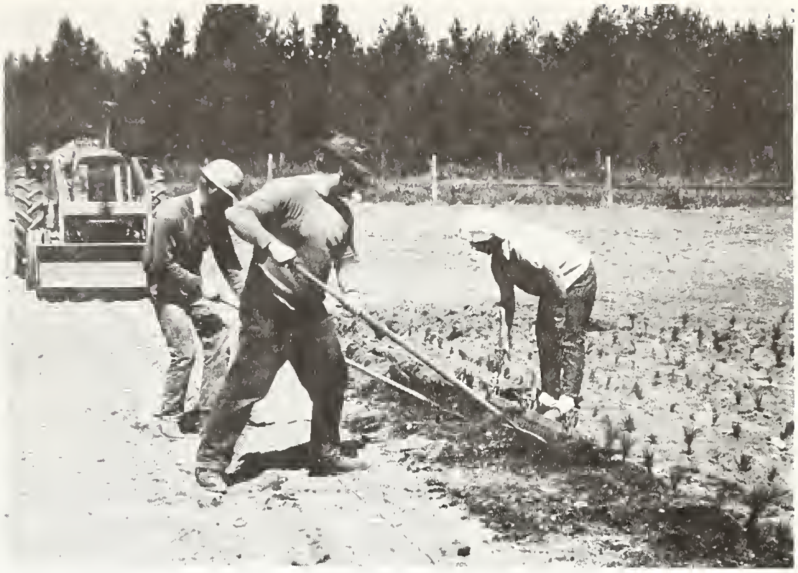


Figure 1.--Plowing the trench for planting a row of trees in the "Variable-Moisture-Stress-Plots."

Figure 2.--After trees are threaded into "Yale board" accurately positioned, the trench is backfilled and uniformly packed around seedling roots.



After planting, all plots are kept moist until late June or early July, when the "stressing" is started. At the start of the stressing period, special irrigation equipment[2] is installed on the low-stress plot (fig. 3). (Other less elaborate systems could be used. Overhead oscillating sprinklers have given good results if the low stress plot is placed to prevent inadvertent irrigation of the adjacent higher stress plots.) Low-stress plots are maintained weed-free to reduce the need for irrigation as much as possible. Soil-moisture-metering devices, either electrical resistance units or tensiometers, have been used to indicate soil moisture content and to provide information for irrigation control. The soils on the low-stress plots are kept roughly above 50 percent of available moisture at the 8-inch level. Stress levels on the other plots are controlled by the degree to which weed competition is removed, and they are varied according to the species planted. For ponderosa pine (*Pinus ponderosa* Laws.) and Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), we aim for a wide range of soil moisture--from the irrigated weed-free plots to a nonirrigated plot having a full component of weeds. With species that demand more moisture, such as western white pine

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[2] LeRoy Schultz and Roland Stoleson. A precision sprinkler for soil moisture studies. Tree Planters' Notes 18(1): 15-17, illus. 1967.

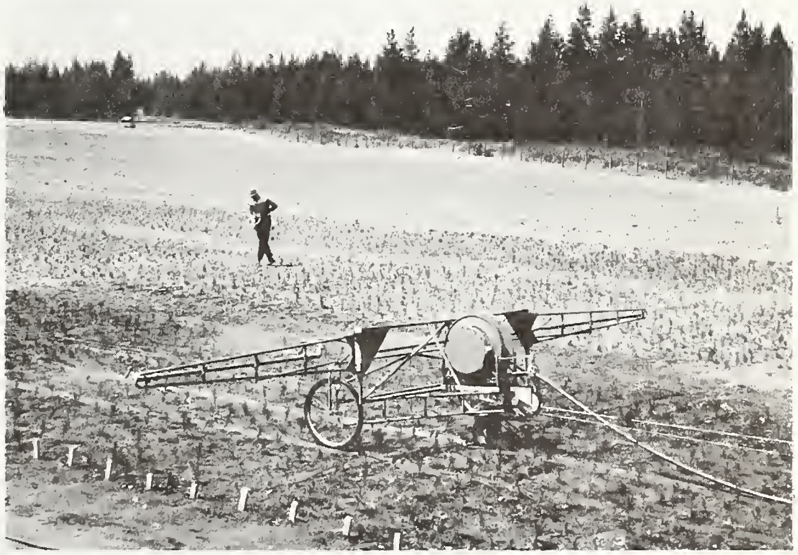

Figure 3.--Overview of "Variable-Moisture-Stress-Plots" with automatic irrigator operating on the low-stress plot area.

(*Pinus monticola* Dougl.), Engelmann spruce (*Picea engelmannii* Parry), and grand fir (*Abies grandis* (Dougl.) Lindl.), we aim for a narrower range of soil moisture by partial weeding of the severe-stress plots and complete weeding of the moderate-stress plots.

The end result for which we aim is a range of survival from near 100 percent in the low-stress plot to 40 percent or less in the severe-stress regime. Theoretically, if we were to use enough stress levels, we should be able to find the level at which differences in survival and growth among the groups of stock being tested are the greatest. In actual practice we have found that three stress levels, judiciously controlled and varied according to the species being studied, are adequate for our purposes.

RESULTS

The moisture-stress-plot technique has been used to test the effects on survival of (a) seedbed density (fig. 4), (b) antitranspirant treatment of stock (fig. 5), (c) age classes (fig. 6), and (d) soil fumigation (fig. 7). It is currently being used in a test of stock storage methods on survival. Although the details of these tests are not included in this report, certain highlights are discussed to illustrate the effectiveness of the method and how to evaluate the results.

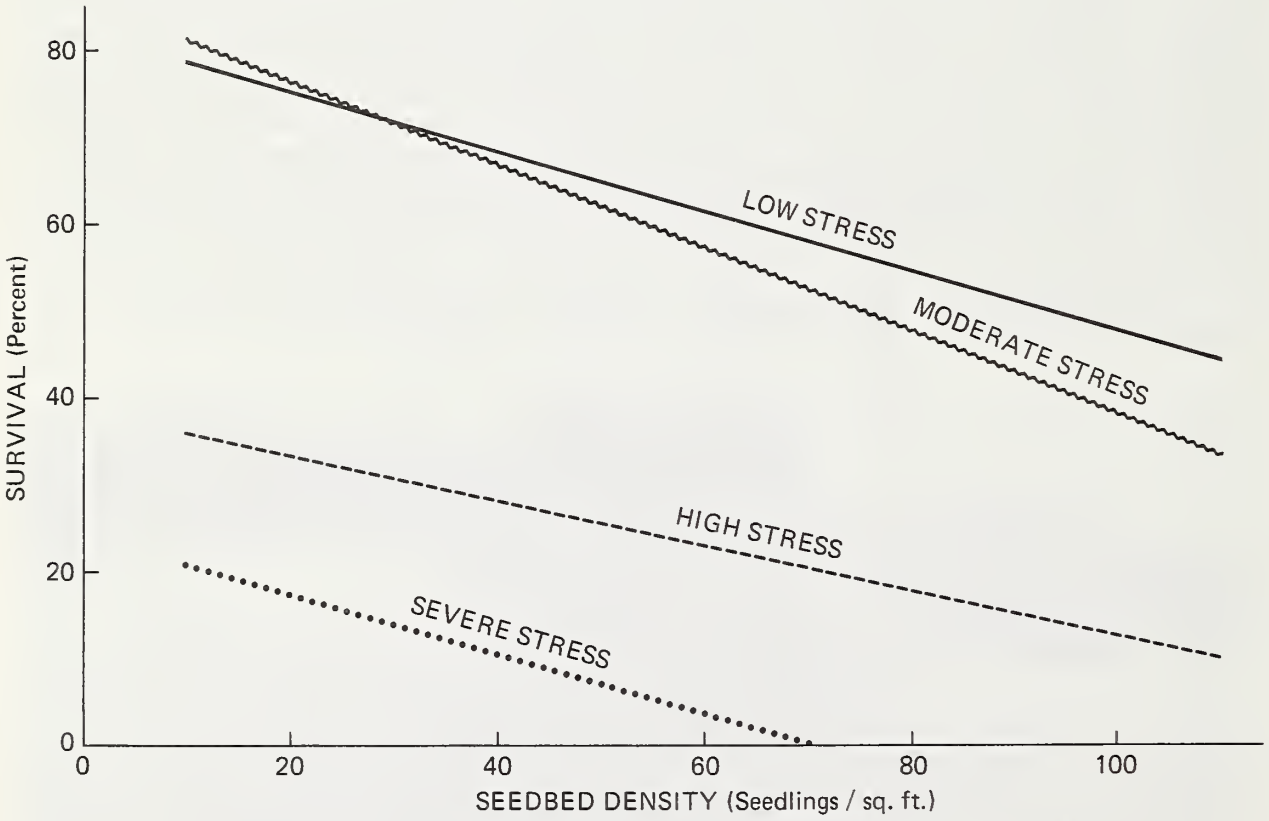

Figure 4.--The effect of seedbed density on survival of 2-0 ponderosa pine at various soil-moisture-stress levels (as of August 20).

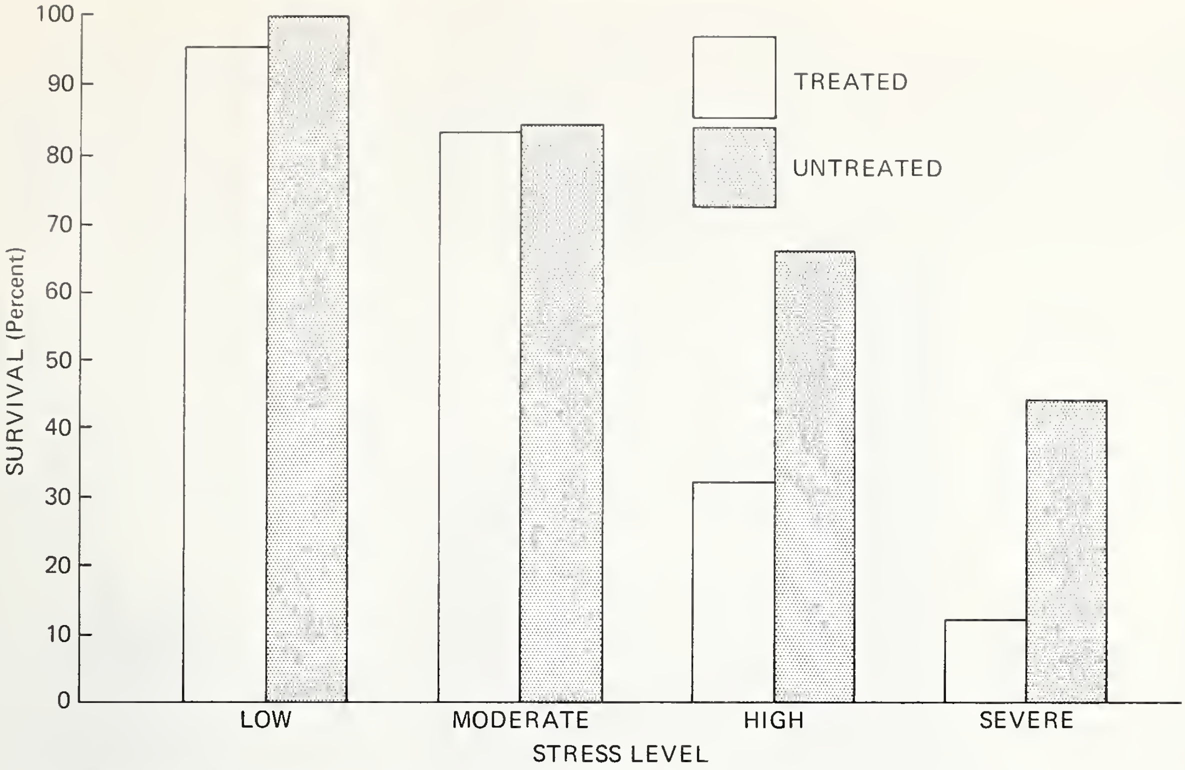

Figure 5.--The effect of antitranspirant treatment on the August 20 survival of 2-1 Douglas-fir growing at various moisture-stress levels.

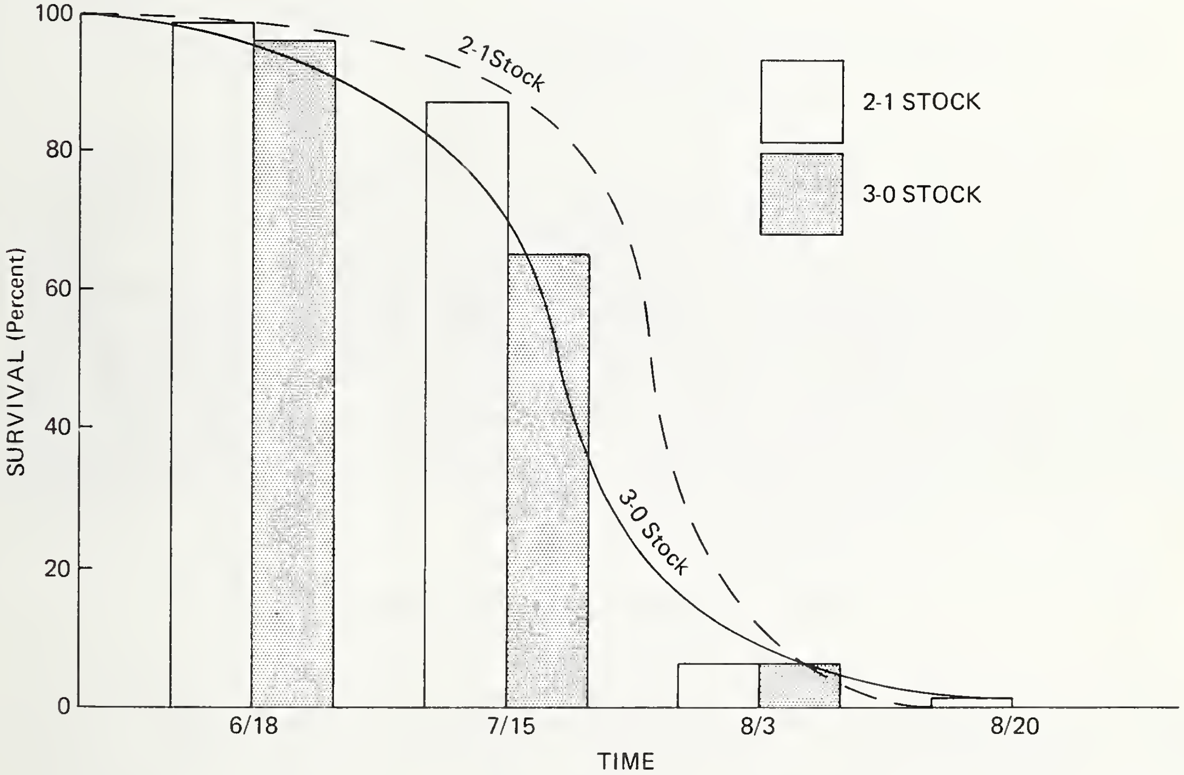

Figure 6.--First-year survival trends of 2-1 and 3-0 Engelmann spruce under severe soil-moisture stress.

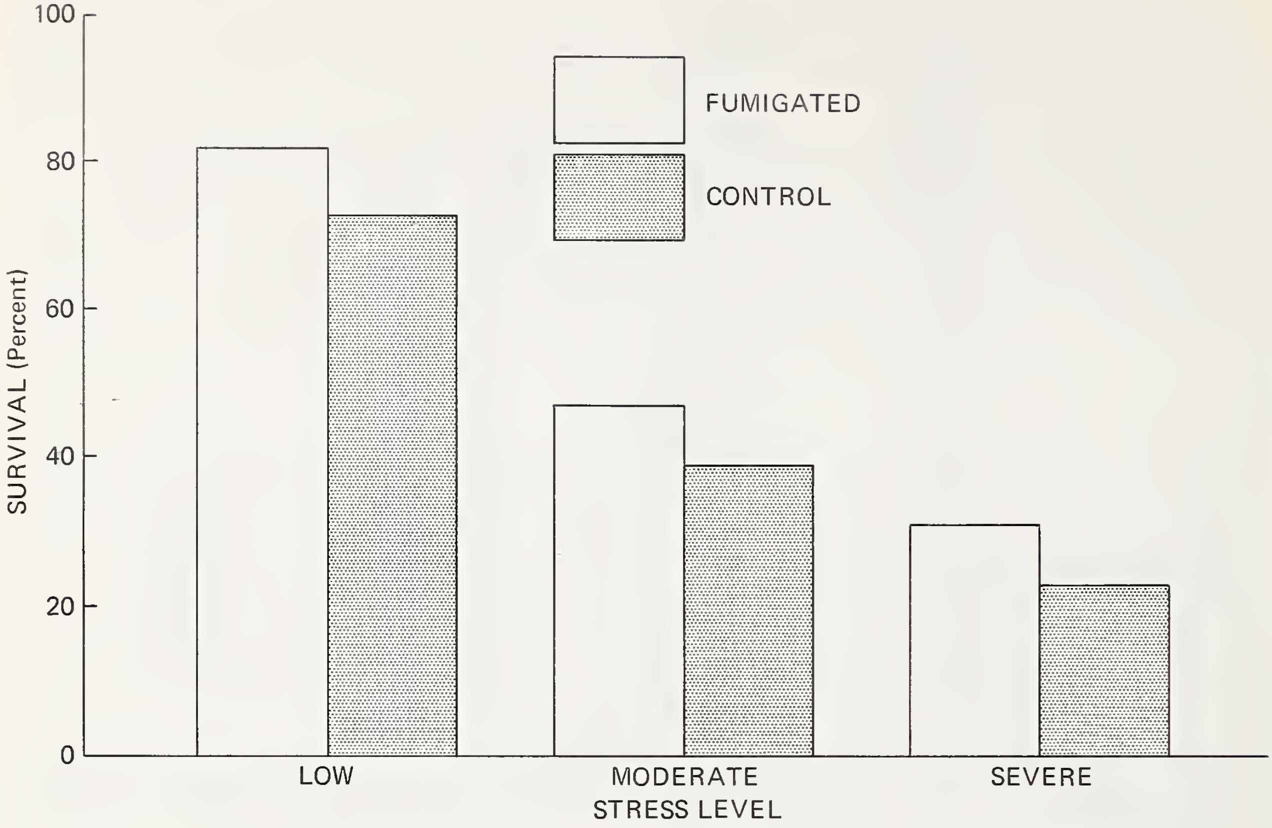

Figure 7.--Moisture-stress-plot survival of 2-0 Douglas-fir stock grown in fumigated and unfumigated seedbeds (survival as of September).

Effects of Seedbed Density

In one of the first applications of the stress plot technique, 2-0 ponderosa pine grown at various seedbed densities was planted and subjected to four stress levels. Results (fig. 4) show a positive effect of low density on survival at all stress levels. In this early trial, luxuriant growth of weeds in the low-stress plots probably caused a greater stress than was anticipated or desired. Ideally, the low-stress plot should serve more as a check on the ability of the trees to survive under favorable conditions than on the effects of the basic study variable on survival. In subsequent uses of the "Variable-Moisture-Stress-Plot" technique, the low-stress plot was kept completely weeded to reduce soil moisture depletion rates and the possibility of inadvertent stressing of test seedlings.

Effect of Antitranspirant Treatment

In this trial, the effects of a chemical antitranspirant, decynyl succinic acid, on survival of 2-0 Douglas-fir was tested at four stress levels. Under low and moderate stress, stock survival was uniformly high whether treated or not (fig. 5). Similar results might be expected in field tests conducted in years of abundant growing season precipitation. At high and severe stress levels, the chemical had a strongly inhibitory effect on survival. Thus, by testing under a wide range of stress, differences were found that would have gone undetected at low- or moderate-stress levels.

Effect of Different Age Classes

The desirability of periodic examination of trees in the stress plot for maximum information was demonstrated in tests comparing the survival of 2-1 and 3-0 Engelmann spruce (fig. 6). Late in the stress cycle, most of the trees had died; therefore no differences could be traced to age-class effects. However, midway through the stress cycle (July 15), obvious differences existed that demonstrated that the 2-1 stock had a superior survival potential. Without the timely examination at about the middle of the test period, this difference in survival capability would have gone unnoticed.

In another test to compare the effect of age class, both 1-0 and 2-0 stock of ponderosa pine and of Douglas-fir were planted at three stress levels. Survival of 1-0 and 2-0 ponderosa pine was not significantly different at any of the stress levels (99 vs. 98 percent, respectively, at low stress; 80 vs. 85 percent at moderate stress; and 47 vs. 54 percent at high stress). The survival of 1-0 Douglas-fir stock was significantly poorer than that of 2-0 stock at all stress levels (86 vs. 95 percent at low stress, 31 vs. 44 percent at moderate stress, and 5 vs. 18 percent at high stress). Subsequent field tests under a variety of field conditions using 1-0 and 2-0 stock of these species have verified the results of the "Variable-Moisture-Stress-Plot" tests.

Effects of Seedbed Fumigation

Planting stock of ponderosa pine, Douglas-fir, and western white pine grown in either fumigated or unfumigated soils have been "survival-tested" in the moisture-stress plots; results have been both positive and negative.[3] Douglas-fir stock grown in fumigated seedbeds survived and grew better under moderate and severe moisture stress than did stock taken from unfumigated beds (fig. 7). Survival of ponderosa pine grown in fumigated soil at one nursery was decreased by fumigation; at another nursery, there was a tendency (although statistically nonsignificant) for better survival of stock that had been grown in unfumigated soil. There was no evidence that white pine stock survival was affected by fumigation.

DISCUSSION AND CONCLUSIONS

Moisture-stress-plot evaluation of nursery stock performance has proven to be a valuable and efficient adjunct to field testing. The technique combines many of the best features of other systems. It is a direct approach, as is field testing, but it is quicker. It has many of the control features of the more indirect scientific techniques, but it is suitable for mass testing and broader inferences. Through continued use and experimentation, we hope to improve the system. We experienced greater variation in our test results than was anticipated, which probably resulted from fluctuations in stress caused either by (a) irrigation irregularities during the month or two preceding the start of the stress cycle, or (b) soil and weed competition differences within a given stress-level plot. Greater care during the pre-stress period and better control of competition might help reduce these variations and render the technique more sensitive statistically. If not, more replications (we generally used three) of test comparisons could be incorporated into the design.

It is virtually impossible to predict actual field survival or field survival differences from the results of this type of testing. The purpose of the technique is to determine whether potential survival or growth differences exist. If they do, the degree of moisture stress at which they become evident may indicate their relative importance when applied to field situations. Field-survival differences are so dependent on the natural variations in climatic conditions from year to year that a truly valid estimate of them would entail field testing for a number of years.

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[3] R. J. Boyd. Effects of soil fumigation on production of conifer nursery stock at two Northern Rocky Mountain nurseries. USDA Forest Serv. Res. Pap. INT-91, 19 p., illus. 1971.

If treatment-caused survival differences are detected using the "Variable-Moisture-Stress-Plot" technique, the decisions regarding the use of nursery treatments should be made on the basis of cost, a fairly rough estimate of possible survival and growth differences, and other possible effects of the treatment. Should the results of a careful evaluation of the situation still leave the decision questionable--the possible consequences of a wrong decision are very costly--long-term field testing would probably be warranted before adopting a questionable practice.

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